14Sep23

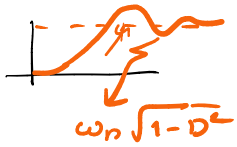
Thursday, September 14, 2023 6:00 PM

Todays class

1. Completing: Setting of controllers
2. Ziegler Nichols Methods.

Break

3. How to AC motors work?
   AC motors should actually be called
   Rotating machines ✓.



$s^2 + 2D\omega_n s + \omega_n^2$

Recap.

den: $T_m \cdot T_a s^2 + T_m s + 1 \rightarrow s^2 + s \cdot \frac{1}{T_a} + \frac{1}{T_m T_a} = 0$

$T_m = r_a T_j$

$s_{1,2} = \sigma_1 \pm j\omega$
complex conjugates.

$\omega_n = \frac{1}{\sqrt{T_m T_a}}$ $D = \frac{1}{2}\sqrt{\frac{T_m}{T_a}}$.

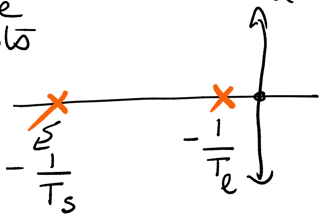
$s_{1,2} = -\frac{1}{2T_a} \pm \sqrt{\frac{1}{4T_a^2} - \frac{1}{T_m T_a}}$.

$T_m > 4T_a$

$s_{1,2} \rightarrow$ negative real roots

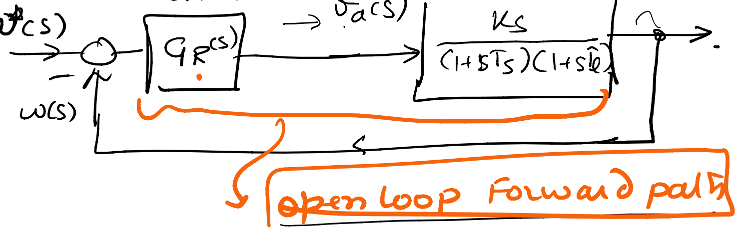
$T_m \cdot T_a s^2 + T_m s + 1 = 0$

$(1 + T_s s)(1 + T_\ell \cdot s) = 0$

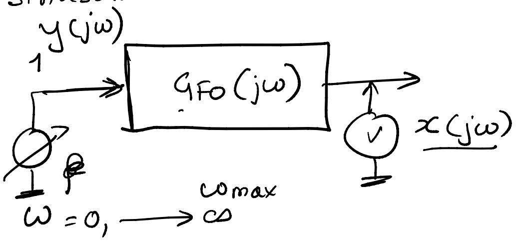


$G_S(s) = \frac{K_s}{(1+T_s s)(1+T_\ell s)} = \frac{\omega(s)}{v_a(s)}$

$s = \sigma + j\omega$



Sinusoids.



$G_{FO} = G_R(s) \cdot G_S(s)$

bode

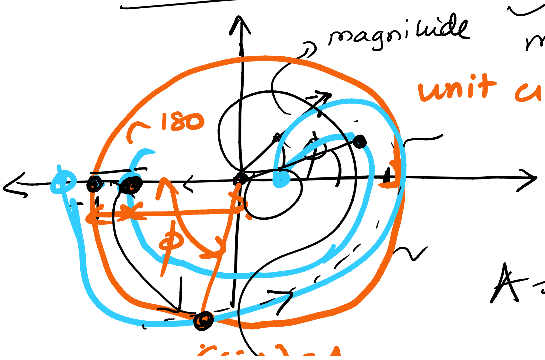
Frequency response.

$x(j\omega) = G_{FO}(j\omega)\, y(j\omega)$

$G_S(j\omega) = \frac{K_s}{(1+j\omega T_s)(1+j\omega T_\ell)}$

Complex number $= |G_{FO}(j\omega)| \angle \phi \leftarrow$ phase of $G(j\omega)$

magnitude



$G_c(j\omega) = \frac{G_{FO}(j\omega)}{1 + G_{FO}(j\omega)}$

$A = \frac{1}{|G_{FO}(j\omega)|}$

$1 + G_{FO}(j\omega) = 0$

$|G_{FO}(j\omega)| = (1)$

$$A = \frac{1}{|G_{FO}(j\omega)|}$$

$1 + G_{FO}(j\omega) = 0$

$$\boxed{|G_{FO}(j\omega)| = 1}$$

$G_{FO}(j\omega) = e^{j\phi}$

$$\boxed{\begin{matrix} 30^\circ < \phi_m < 60^\circ \\ 2 < A < 6 \end{matrix}}$$

Magnitude optimum e is error. $\int_0^\infty |e| \cdot dt \rightarrow \min.$

1. compensate the larger time constant with PI $\rightarrow$ zero.
2. $PI = G_R(s) = K_R \dfrac{(T_i s + 1)}{T_i s}$

$$\boxed{\begin{matrix} T_i = T_\ell . \\ K_R = \dfrac{T_\ell}{2 \cdot K_S \cdot T_S} \end{matrix}}$$

Symmetrical optimum

$T_i = a^2 T_S .$

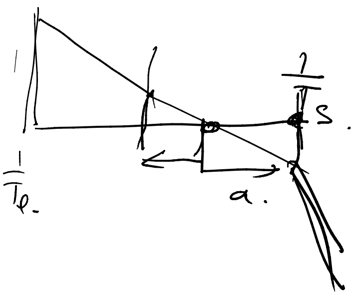
$K_R = \dfrac{T_\ell}{a \cdot K_S \cdot T_S} .$

$T_\ell > T_S$

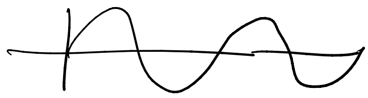
$(1 + s \cdot T_\ell)$

$T_\ell >> 1 . \frac{1}{T_\ell}$

$(s T_\ell)$



AC Motor is really Not an AC motor



They should be called

Rotating Field Machines

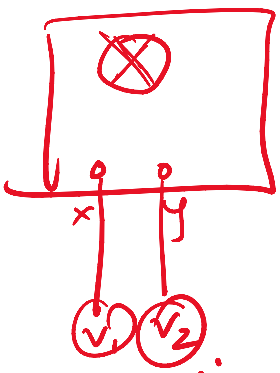
$x = 1 . \cos(\omega t)$

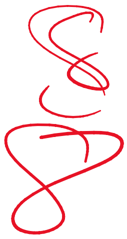
$y = 1 . \cos(\omega t)$

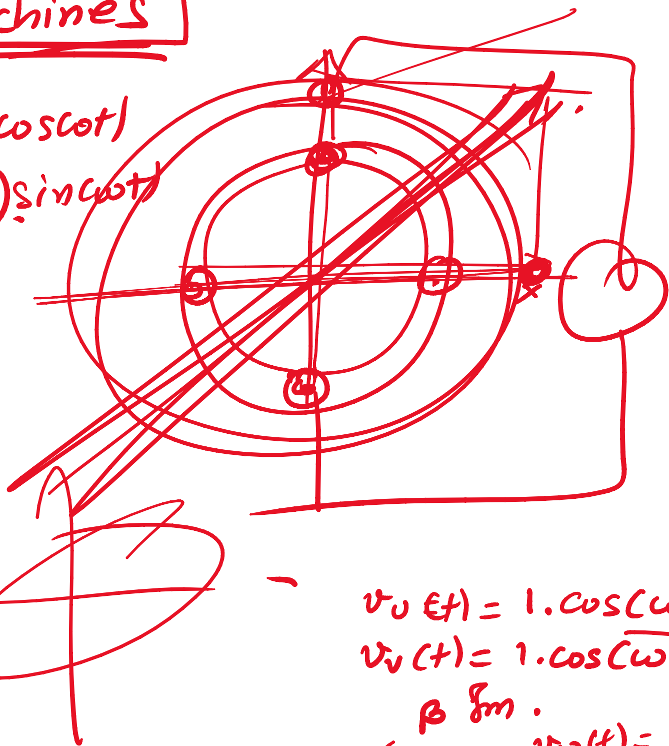
Lissajous Figures

$x = 1 \cos(\omega t)$

$y = 1 \sin(\omega t)$







$v_U(t) = 1 . \cos(\omega t)$

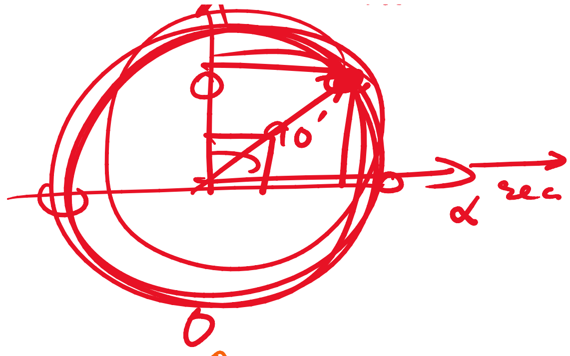
$v_V(t) = 1 . \cos(\omega t - 2\pi/3)$

$v_W(t) = 1 . \cos(\omega t - 4\pi/3)$

$x(t) = 1.\cos(\omega t)$ ←

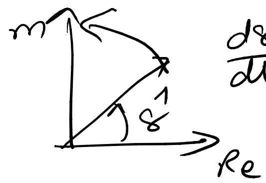
$y = 1.\sin(\omega t)$

$$\boxed{\vec{r} = x(t)\cdot\vec{i} + y(t)\cdot j}$$



$\vec{r} = 1\cdot\cos(\omega t) + j\sin(\omega t)$

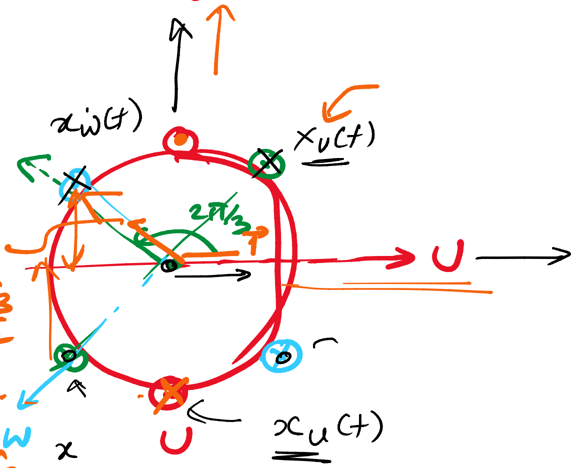
$= 1 e^{j\omega t}$



$\frac{d\delta}{dt} = \omega$

$\vec{a} = 1e^{j\frac{2\pi}{3}}$

$= -\frac{1}{2} + j\frac{\sqrt{3}}{2}$



$\vec{a}^2 = 1e^{j\frac{4\pi}{3}}$

$= -\frac{1}{2} - j\frac{\sqrt{3}}{2}$

$\vec{r} = r_\alpha + j r_\beta$

$r_\alpha = x_u(t)\cdot 1 + Re(a)\cdot x_v(t) + Re(a^2)\cdot x_w(t)$

$r_\beta = Im(a)\cdot x_v(t) + Im(a^2)\cdot x_w(t)$

$\vec{r} = r_\alpha + j r_\beta = x_u(t)\cdot 1 + \vec{a}\cdot x_v(t) + \vec{a}^2\cdot x_w(t)$ $\quad \omega = 2\pi\cdot 50$

$\vec{r}$ at $t = 5ms$

$x_u(t) = 1\cdot\cos(\omega t)$

$x_v(t) = 1\cdot\cos(\omega t - 2\pi/3)$

$x_w(t) = 1\cdot\cos(\omega t - 4\pi/3)$

$r = r_\alpha = 1\cdot\cancel{\cos(\omega t)} + j\, 1\sin(\omega t)$